IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application

Inventor(s): ANDREW ROMAN CHRAPLYVY et al.
Case: CHRAPLYVY 28-3-1-7 (LCNT/124225)
Serial No.: 09/990,964 **Group Art Unit:** 2613
Filed: 11/21/2001
Examiner: Lee, David J.
Title: LONG HAUL TRANSMISSION IN A DISPERSION MANAGED OPTICAL COMMUNICATION SYSTEM

CERTIFICATE OF MAILING OR TRANSMISSION
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SIR:

DECLARATION UNDER 37 C.F.R. 1.132

1. I, Andrew Roman Chraplyvy, am a Vice-President of the Optical Networks Research Center at Bell Laboratories, Alcatel-Lucent, and I am one of the inventors of the subject application. I have worked in the broad field of data communications and networking for more than 30 years, and I have been specifically involved with long haul transmission for more than 25 years. I have a Ph.D. degree in Physics from Cornell University.

2. I, Adriaan J. de Lind van Wijngaarden, am a Member of Technical Staff in the Communications and Statistical Sciences Department at Bell Laboratories, Alcatel-Lucent, and I am one of the inventors of the subject application. I have worked in the broad field of data communications and networking for 9 years, and I have been specifically involved with long haul transmission for 8 years. I have a Ph.D. degree in Engineering from the University of Essen, Essen, Germany.

3. I, Gerhard Kramer, am a Member of Technical Staff at the Communications and Statistical Sciences Department at Bell Laboratories, Alcatel-Lucent, and I am one of the inventors of the subject application. I have worked in the broad field of data communications and networking for 9 years, and I have been specifically involved with long haul transmission for 7 years. I have a Ph.D. degree in Engineering from the ETH Zürich, Switzerland.

4. I, Xiang Liu, am a Member of Technical Staff (position), in Optical Networks (Department) at Bell Laboratories, Alcatel-Lucent, and I am one of the inventors of the subject application. I have worked in the broad field of data communications and networking for 8 years, and I have been specifically involved with long haul transmission for 7 years. I have a Ph.D. degree in Applied Physics from Cornell University.

5. Exhibits A-C are attached as supporting evidence of the research activities and technical advances reported as post-deadline papers in various sessions at the Optical Fiber Communication Conferences (OFC) from 2001 to 2005.

6. The OFC has been one of the largest international conferences in the field of optical communications since late 1990's, and is well-attended by scientists and engineers from around the world.

7. The post-deadline session is a forum for reporting the latest research activities and developments submitted after the normal deadline of paper submission.

8. Exhibit A is a copy of the post-deadline program for the Optical Fiber Transmission session of OFC 2002 held in Anaheim, California, USA.

9. Page 2 of Exhibit A shows a paper FC2 by Gnauck et al., entitled "2.5 Tb/s (64 x 42.7 Gb/s) transmission over 40 x 100km NZDSF using RZ-DPSK format and all-

Raman-amplified spans." The paper was co-authored by three inventors of the subject application: X. Liu, C. Xu and X. Wei, of Bell Laboratories, Lucent Technologies, Inc. (which became Alcatel-Lucent in 2006).

10. Experimental results reported in the FC2 paper were obtained using a method with dispersion managed return-to-zero (RZ) differential phase shift keying (DPSK), which is a part of the subject matter of the present application, S/N 09/990,964. This was the only report on RZ-DPSK transmission in the post-deadline Optical Fiber Transmission session in OFC 2002.

11. Exhibit B is a copy of the program for the post-deadline papers on Optical Fiber Transmission at OFC 2001, held in Anaheim, California, USA.

12. Exhibit B shows that there was no report on RZ-DPSK in that session at OFC 2001.

13. Exhibit C is a copy of the programs for various post-deadline sessions in OFC 2003, 2004 and 2005, all held in the USA.

14. Pages 1-3 of Exhibit C show the post-deadline program in the Optical Fiber Transmission session of OFC 2003. Page 2 of Exhibit C shows that, out of a total of ten (10) papers in this post-deadline session, five (5) of them -- namely, PD18, PD19, PD20, PD22 and PD23, relate to dispersion managed RZ-DPSK transmission.

15. The original FC2 paper submitted by Lucent Technologies, Inc. in 2002 is directly referenced in papers PD18, PD20, PD22 and PD23, and indirectly referenced in PD19.

16. Pages 4-5 of Exhibit C show the post-deadline program for the session on Digital Transmission Systems at OFC 2004. Page 5 of Exhibit C shows that, out of a total of five (5) post-deadline papers in this session, three (3) of them -- namely, PDP34, PDP35, and

PDP37 relate to dispersion managed RZ-DPSK transmission, while PDP 38 relates to dispersion managed RZ-DQPSK transmission.

17. Pages 6-8 of Exhibit C show the post-deadline program for the session on Digital Transmission Systems at OFC 2005. Pages 7-8 of Exhibit C show that, out of a total of four (4) post-deadline papers in this session, three (3) of them relate to RZ-DPSK transmission. Specifically, PDP26 relates to RZ-DPSK with dispersion compensation at the receiver, PDP27 relates to RZ-DPSK transmission without optical dispersion compensation, and PDP28 relates to RZ-DPSK transmission without inline dispersion compensation but with optical phase conjugation.

18. As illustrated in Exhibit C, the author affiliations of these post-deadline papers on RZ-DPSK transmission show a diverse representation from the international community, including several competitors of Lucent Technologies (now Alcatel-Lucent).

19. The original FC2 paper in 2002 is referenced, either directly or indirectly, by most of the above post-deadline RZ-DPSK papers shown in Exhibit C.

The undersigned, Andrew Roman Chraplyvy, Adriaan J. de Lind van Wijngaarden, Gerhard Kramer and Xiang Liu, hereby declare that all statements made herein of my own knowledge are true and that these statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent resulting therefrom.

Date: Sept 13, 2007

Andrew R Chraplyvy

Andrew Roman Chraplyvy

Date: Sept. 13, 2007

Adriaan J. de Lind van Wijngaarden

Date: Sept. 13, 2007

Gerhard Kramer

Date: Sept. 13, 2007

Xiang Liu

Exhibit A p.1

OFC 2002

OPTICAL FIBER COMMUNICATION CONFERENCE AND EXHIBIT

S. Chandrasekhar

Postdeadline Papers

Postdeadline at light speed

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MARCH 22, 2002
ANAHEIM CONVENTION CENTER
ANAHEIM, CA

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IEEE LASERS AND ELECTRO-OPTICS SOCIETY
LEOS

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Optical Society of America

FC 9:00am-11:30am
Room: Room E

Alexei N. Pilipetskii, TyCom (US) Inc., USA, Presider
Lynn Nelson, OFS Fitel Labs., USA, Presider

FC1 9:00am

80x10.7 Gb/s ultra-long-haul (+4200 km) DWDM network with reconfigurable "broadcast & select" OADMs
I. Tomkos, M. Vasilyev, J.K.. Rhee, M. Mehendale, B. Hallock, B. Szalabofka, M. Williams, S. Tsuda, M. Sharma, Corning Inc., USA.
We report the first dynamically reconfigurable ULH network demonstration using "broadcast & select" OADM architecture. We demonstrate 80x10.7 Gb/s NRZ C-band DWDM networking over 4160km of all-Raman amplified dispersion-managed fiber and 13 concatenated OADMs with 2dB Q-margin for 10^{-15} BER operation.

FC2 9:15am

2.5 Tb/s (64 x 42.7 Gb/s) transmission over 40 x 100 km NZDSF using RZ-DPSK format and all-Raman-amplified spans
A.H. Gnauck, G. Raybon, S. Chandrasekhar, J. Leuthold, C. Doerr, L. Stulz, A. Agarwal, S. Banerjee, D. Grosz, S. Hunsche, A. Kung, A. Marhelyuk, D. Maywar, M. Movagassaghi, X. Liu, C. Xu, X. Wei, D.M. Gill, Lucent Tech., Bell Labs., USA.
We report 2.5 Tb/s (64 x 42.7-Gb/s) WDM transmission over 4000 km (forty 100-km spans) of non-zero dispersion-shifted fiber. This capacity x distance record of 10 petabit-km/s for 40-Gb/s systems is achieved in a single 53-nm extended L band using return-to-zero differential-phase-shift-keyed modulation, balanced detection, and distributed Raman amplification.

FC3 9:30am

2.56 Tb/s (256x10 Gb/s) transmission over 11,000 km using hybrid Raman/EDFAs with 80 nm of continuous bandwidth
D.G. Foursa, C.R. Davidson, M. Nissov, M.A. Mills, L. Xu, J.X. Cai, A.N. Pilipetskii, Y. Cai, C. Brevernan, R.R. Cordell, T.J. Carvelli, P.C. Corbett, H.D. Kidorf, Neal S. Bergano, Tyco Telecommunications, USA.
Two hundred and fifty six 10 Gb/s WDM channels were transmitted over 11,000 km in 80 nm of continuous optical bandwidth of hybrid Raman/EDFA for the first time. Using FEC all channels were decoded error free.

FC4 9:45am

Transmission of thirty-eight 40 Gb/s channels (>1.5 Tb/s) over transoceanic distance
J.-X. Cai, M. Nissov, C.R. Davidson, Y. Cai, A.N. Pilipetskii, H. Li, M.A. Mills, R.-M. Mu, U. Feiste, L. Xu, A.J. Lucero, D.G. Foursa, Neal S. Bergano, Tyco Telecommunications, USA.
Thirty-eight 40 Gb/s channels were transmitted over 6,200 km for a total capacity of 1.52 Tb/s. This is the first transoceanic length DWDM demonstration using 40 Gb/s channels. In addition, we show 60% spectral efficiency over 4,500 km without the need of polarization demultiplexing.

FC5 10:00am

Transmission of 256 wavelength-division and polarization-division-multiplexed channels at 42.7Gb/s (10.2Tb/s capacity) over 3x100km of TeraLight™ fiber
Yann Frignac, Gabriel Charlet, Wilfried Idler, Roman Dischler, Patrice Tran, Stéphanie Lanne, Sophie Borne, Catherine Martinelli, Gustav Veith, Amaury Jourdan, Jean-Pierre Hamaide, Sébastien Bigo, Alcatel Res. and Innovation, France.

10.2Tb/s capacity is demonstrated over 3x100km in C and L bands, using 42.7Gb/s channels. The wavelength allocation was chosen while taking into account narrow optical filtering at the transmitter and receiver ends and second-order Raman pumping is used to improve the signal-to-noise ratio.

FC6 10:15am

6,050km transmission of 32 x 42.7 Gb/s DWDM signals using Raman-amplified quadruple-hybrid span configuration
Hiroto Sugahara, Kiyoshi Fukuchi, Akihiro Tanaka, Yoshihisa Inada, Takashi Ono, NEC, Japan.
We demonstrate the first transatlantic distance transmission of 40-Gb/s-based dense-WDM signals with 100-GHz channel spacing. This successful transmission was achieved by suppression of fiber nonlinear effect enabled by distributed all-Raman amplification and a quadruple-hybrid span configuration.

Exhibit A p.3

FC7 10:30am

1.6 Tbit/s (40x42.7 Gbit/s) transmission over 3600 km UltraWave™ fiber with all-Raman amplified 100 km terrestrial spans using ETDM transmitter and receiver

Fenghai Liu, Jon Bennike, Supriyo Dey, Christian Rasmussen, Benny Mikkelsen, Pavel Mamyshev, Mintera Corp., USA; Denis Gapontsev, Vladlen Ivshin, IPG Photonics Corp., USA

We demonstrate error free transmission of 40x40 Gbit/s over a record distance of 36x100 km UltraWave™ dispersion managed fiber with all-Raman amplification and 100 GHz channel spacing. CS-RZ modulation and 43 Gbit/s ETDM transmitter and receiver are used.

FC8 10:45am

3.2Tb/s (80 x 42.7Gb/s) transmission over 20 x 100km of non-zero dispersion fiber with simultaneous C + L-band dispersion compensation

B. Zhu, L. Leng, L.E. Nelson, L. Gruner-Nielsen, Y. Qian, J. Bromage, S. Stulz, P. Gaarde, A. Judy, B. Palsdottir, R.L. Lingle, Jr., OFS, USA; S. Kado, Y. Emori, S. Namiki, Fitel Photonics Lab., Japan.

Error-free transmission of eighty 40-Gb/s, 100-GHz spaced channels over 2000 km of TrueWave® REACH fiber is achieved. We employ 100-km all-Raman-amplified spans, dispersion-slope-matched dispersion compensating fiber modules covering a 75-nm band, carrier-suppressed return-to-zero modulation format, and forward error correction.

FC9 11:00am

Field trial of 63 channels 40 Gbit/s dispersion-managed soliton WDM signal transmission over 320 km NZ-DSFs

T. Otani, M. Hayashi, M. Daikoku, K. Ogaki, Y. Nagao, K. Nishijima, M. Suzuki, KDDI R&D Labs, Inc., Japan.

Field trial of 63 channels 40Gbit/s dispersion-managed soliton WDM signal transmission was successfully demonstrated over 320km(4x80km) installed NZ-DSFs. The obtained Q factor on average was 15.4dB, and very stable long-term performance was confirmed without PMD compensation.

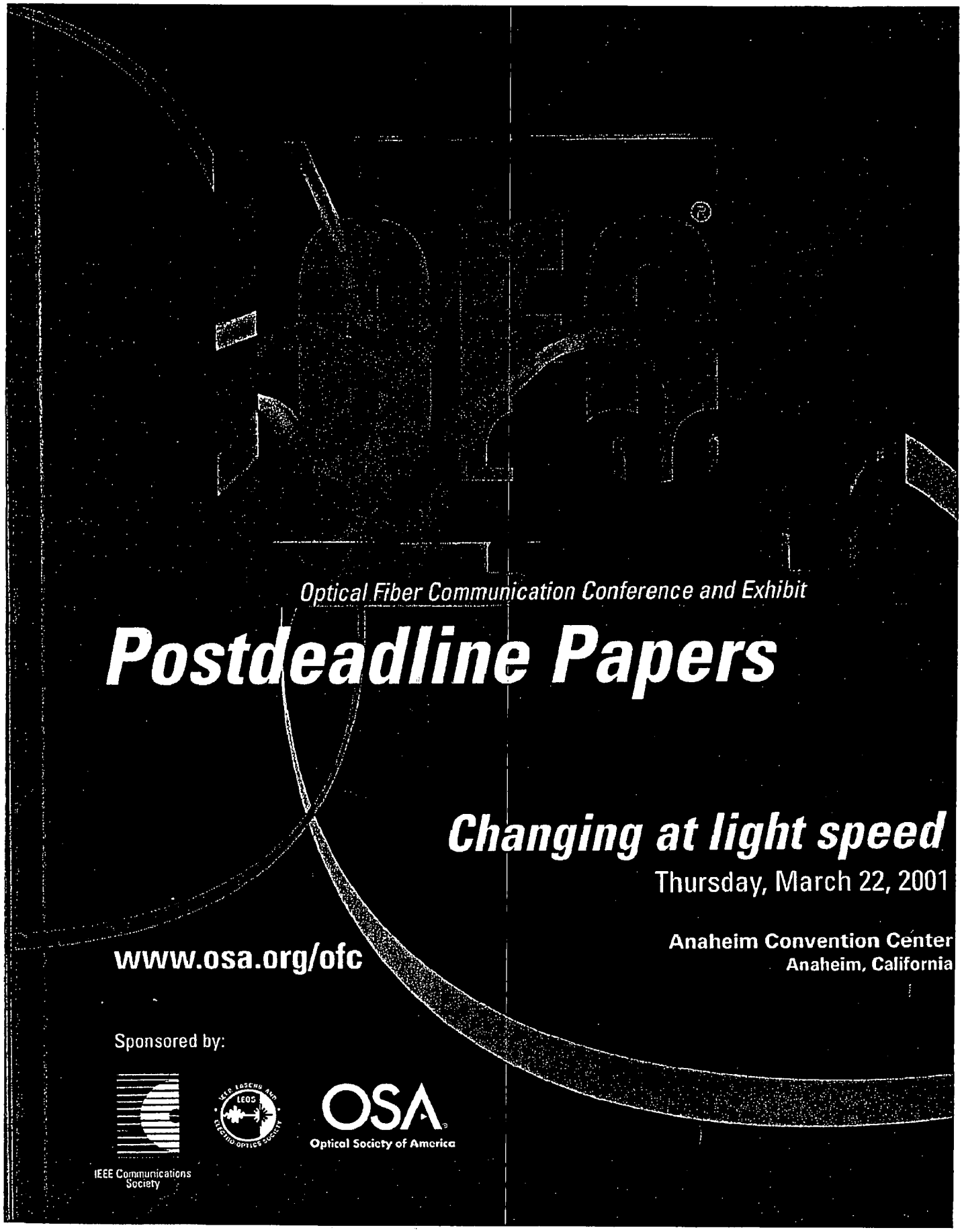
FC10 11:15am

40 channels 4000 km DWDM ULH transmission field trial without Raman amplification and regeneration

David Chen, Steve Wheeler, Dung Nguyen, Bobby Davis, WorldCom, USA; Mirko Glavanovic, John Khaydarov, Igor Koruga, Steve Hegarty, Fuad Cokic, Fei Zhu, OptiMight Communications, USA.

This paper reports a field trial transmission carrying live voice, data, and video traffic without using Raman amplification and regeneration across an ultra-long haul DWDM transport system of installed SSMF using conventional EDFAs only.

Exhibit B p.1



Optical Fiber Communication Conference and Exhibit

Postdeadline Papers

Changing at light speed

Thursday, March 22, 2001

www.osa.org/ofc

Anaheim Convention Center
Anaheim, California

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IEEE Communications Society

IEEE LASERS AND ELECTRO-OPTICS SOCIETY LEOS

OSA Optical Society of America

Exhibit B
12.2

PD16 11:00am
All-optical nonblocking terabit/s crossconnect based on low power all-optical wavelength converter and MEMS switch fabric,
J. Leuthold, R. Ryf, S. Chandrasekhar, D.T. Neilson, C.H. Joyner, C.R. Giles, Bell Labs., Lucent Tech., USA.
All-optical nonblocking routing of 80 10 Gb/s C-band channels is demonstrated with a 100x100 optical crossconnect. Enabling technology is a channel equalizing low-power wavelength converter operating with -14 dBm input power such that no single channel amplification is needed.

PD17 11:15am
High brightness cavity-controlled surface emitting GaInAs lasers operating at 980 nm,
Aram Mooradian, Novalux, Inc., USA.
Cavity controlled, electrically pumped GaInAs lasers have demonstrated over one watt cw multi-mode and up to 0.5 watts cw in a TEM00 mode in a single frequency with 90% coupling efficiency into a single-mode fiber.

PD18 11:30am
1400-1480 nm ridge-waveguide pump lasers with 1 watt CW output power for EDFA and Raman amplification,
D. Garbuzov, R. Menna, A. Komissarov, M. Maiorov, V. Khalfin, A. Tsekoun, S. Todorov, J. Connolly, Princeton Lightwave, Inc., USA.
New type of ridge-waveguide pump lasers providing 1 W single-mode radiation power in the 1400-1480 nm wavelength range is reported. We demonstrate fiber coupling efficiency as high as 83% and ex-fiber power of 710 mW.

PD19 11:45am
Multi Gbit/s, high-sensitivity all silicon 3.3V optical receiver using PIN lateral trench photodetector,
Jeremy D. Schaub, Daniel M. Kuchta, Dennis L. Rogers, Min Yang, Ken Rim, IBM, USA; Steven Zier, Michael Sorna, IBM Microelectronics Division, USA.
We report a 3.3V silicon optical receiver consisting of a CMOS-compatible lateral trench PIN photodiode and a transimpedance amplifier that achieved a sensitivity of -17.1dBm at 2.5Gb/s and demonstrated error-free (BER<10^-10) operation up to 6.5Gb/s at 845nm. This is the highest reported sensitivity at data rates above 2.0Gb/s and the fastest operation of any Si-based optical receiver.

10:15am—12:00pm

Ballroom C—D
Valeria Dasilva, Corning, Inc., USA, Presider

PD20 10:15am
2.4 Tb/s (120 x 20 Gb/s) transmission over transoceanic distance using optimum FEC overhead and 48% spectral efficiency,
J.-X. Cai, M. Nissov, A.N. Pilipetskii, A.J. Lucero, C.R. Davidson, D. Foursa, H. Kidorf, M. A. Mills, R. Menges, P.C. Corbett, D. Sutton, Neal S. Bergano, TyCom Labs, USA.
We have demonstrated 2.4 Tb/s (120 x 20 Gb/s) transmission over the transoceanic distance of 6,200 km using optimum FEC overhead, 48% spectral efficiency, ultra-low slope dispersion map, and full C-band EDFAs.

PD21 10:30am
1 Tbit/s (101 x 10 Gbit/s) transmission over transpacific distance using 28 nm C-band EDFAs,
B. Bakhshi, M.F. Arend, M. Vaa, E.A. Golovchenko, D. Duff, H. Li, S. Jiang, W.W. Patterson, R.L. Maybach, D. Kovsh, TyCom Laboratories, USA.
We present the first Tbit/s transpacific (9000 km) transmission experiment over the EDFA C-band. Using 101 channels at 10 Gbit/s spaced 33 GHz apart, a slope-matched dispersion map and an advanced gain equalization technique, we demonstrate a system margin of 4 dB above the FEC limit.

PD22 10:45am
3Tbit/s (300x11.6Gbit/s)transmission over 7380km using C+L band with 25GHz channel spacing and NRZ format,
G. Vareille, F. Pitel, J-F. Marcerou, Alcatel, France.
We report transmission capacity of 3Tbit/s over 7380km using 300 NRZ channels with 25GHz channel spacing over C+L bands.

Exhibit B
p.3

PD23 11:00am
3.08 Tb/s (77 x 42.7 Gb/s) transmission over 1200 km of non-zero dispersion-shifted fiber with 100-km spans using C- and L-band distributed raman amplification,
B. Zhu, L. Leng, L.E. Nelson, Y. Qian, S. Stulz, H. Thiele, J. Bromage, L. Gruner-Nielsen, S. Knudsen, Lucent Tech., USA; C. Doerr, L. Stulz, S. Chandrasekhar, S. Radic, J. Park, K.S. Feder, Bell Labs Res., USA; D. Vengsarkar, Z. Chen, Agere Sys, USA.
We demonstrate 3.08 Tb/s (77 x 42.7Gb/s) WDM transmission over 1200 km fiber with 100-km amplifier spacing and 100 GHz channel spacing. Error free transmission of all 77 channels is achieved. We employ dual C- and L-band hybrid Raman/Erbium-doped inline amplifiers, experimental low dispersion slope TrueWaveÆ fiber, and Forward Error Correction to achieve this record capacity*distance product at 40-Gb/s.

PD24 11:15am
10.92-Tb/s (273 x 40-Gb/s) triple-band/ultra-dense WDM optical-repeatered transmission experiment,
Kiyoshi Fukuchi, Tadashi Kasamatsu, Masao Morie, Risato Ohhira, Toshiharu Ito, Kayato Sekiya, Daisaku Ogasahara, Takashi Ono, NEC Corp., Japan.
With LD-pumped gain-shifted thulium-doped fiber amplifiers, polarization interleave multiplexing combined with wavelength/polarization demultiplexing for 50-GHz-spaced 40-Gb/s/ch WDM signals, and a transmission line optimization for triple-band systems, the first 10-Tb/s WDM transmission in single fiber using S-, C- and L-bands is demonstrated.

PD25 11:30am
10.2Tbit/s (256x42.7Gbit/s PDM/WDM) transmission over 100km TeraLightô fiber with 1.28bit/s/Hz spectral efficiency,
Sébastien Bigo, Yann Frignac, Gabriel Charlet, Sophie Borne, Patrice Tran, Christian Simonneau, Dominique Bayart, Amaury Jourdan, Jean-Pierre Hamaide, Alcatel Res. and Innovation, France; Wilfried Idler, Roman Dischler, Gustav Veith, Alcatel Res. and Innovation, Germany; Helmut Gross, Wolfgang Poehlmann, Alcatel Terrestrial Networks Div., Germany.
We demonstrate the transmission of 256 polarization-division and wavelength-division multiplexed channels at 42.7Gbit/s rate over 100km of TeraLightô fiber. An overall capacity of 10Tbit/s is achieved in C and L bands at a record 1.28bit/s/Hz spectral efficiency.

PD26 11:45am
2.56Tbit/s (40Gbit/s x 64WDM) unrepeatered 230km transmission with 0.8bit/s/Hz spectral efficiency using low-noise fiber Raman amplifier and 170μm²-Aeff fiber,
Takayuki Miyakawa, Itsuro Morita, Keiji Tanaka, Haruhisa Sakata, Noboru Edagawa, KDD R&D Labs., Inc., Japan.
We have demonstrated 50GHz-spaced 40Gbit/s x 64WDM unrepeatered transmission over 230km using a low-noise Raman amplifier, 170μm²-Aeff fiber and bandlimited RZ signals without polarization-demultiplexing at the receiver. 2.56Tbit/s capacity was transmitted with only 25.8nm bandwidth.

10:15am—11:45am

Room 303 A—D
Gen Ribakovs, Nortel Networks, Canada, Presider

PD27 10:15am
Automatic PMD compensation at 40 Gbit/s and 80 Gbit/s Using a 3-dimensional DOP evaluation for feedback,
H. Rosenfeldt, Ch. Knothe, R. Ulrich, E. Brinkmeyer, Tech Univ. Hamburg, Germany; U. Feiste, C. Schubert, J. Berger, R. Ludwig, H.G. Weber, Heinrich-Hertz Inst., Germany; A. Ehrhardt, T-Nova, Germany.
We demonstrate that polarization scrambling combined with DOP evaluation enables PMD compensation without feedback fading due to varying input polarization. PMD of an installed fiber as well as PMD of an emulator was successfully compensated.

PD28 10:30am
1296-port MEMS transparent optical crossconnect with 2.07 Petabit/s switch capacity,
R.. Ryf, J. Kim, J.P. Hickey, A. Gnauck, D. Carr, F. Pardo, C. Bolle, R. Frahm, N. Basavanhally, C. Yoh, D. Ramsey, R. Boie, R. George, J. Kraus, C. Lichtenwalner, R. Papazian, J. Gates, H. R. Shea, A. Gasparyan, V. Muratov, J.E. Griffith, J.A. Prybyla, S. Goyal, C.D. White, M.T. Lin, R. Ruel, C. Nijander, S. Arney, D. T. Neilson, D. J. Bishop, P. Kolodner, S. Pau, C. Nuzman, A. Weis, B. Kumar, D. Lieuwen, V. Aksyuk, D.S. Greywall, T.C. Lee, H.T. Soh, W.M. Mansfield, S. Jin, W.Y. Lai, H.A. Huggins, D.L. Barr, R.A. Cirelli, G. R. Bogart, K. Teffeau, R. Velta, H. Mavoori, A. Ramirez, N.A. Ciampa, F.P. Klemens, M.D. Morris, T. Boone, J.Q. Liu, J.M. Rosamilia, C.R. Giles, Lucent Tech., USA.
A 1296-port MEMS transparent optical crossconnect with 5.1dB+/-1.1dB insertion loss at 1550nm is reported. Measured worst-case optical crosstalk in a fabric was -38dB and nominal switching rise/fall times were 5msec. A 2.07Petabit/s switch capacity was verified upon cross-connecting a forty-channel by 40Gb/s DWDM data stream through a prototype fabric.

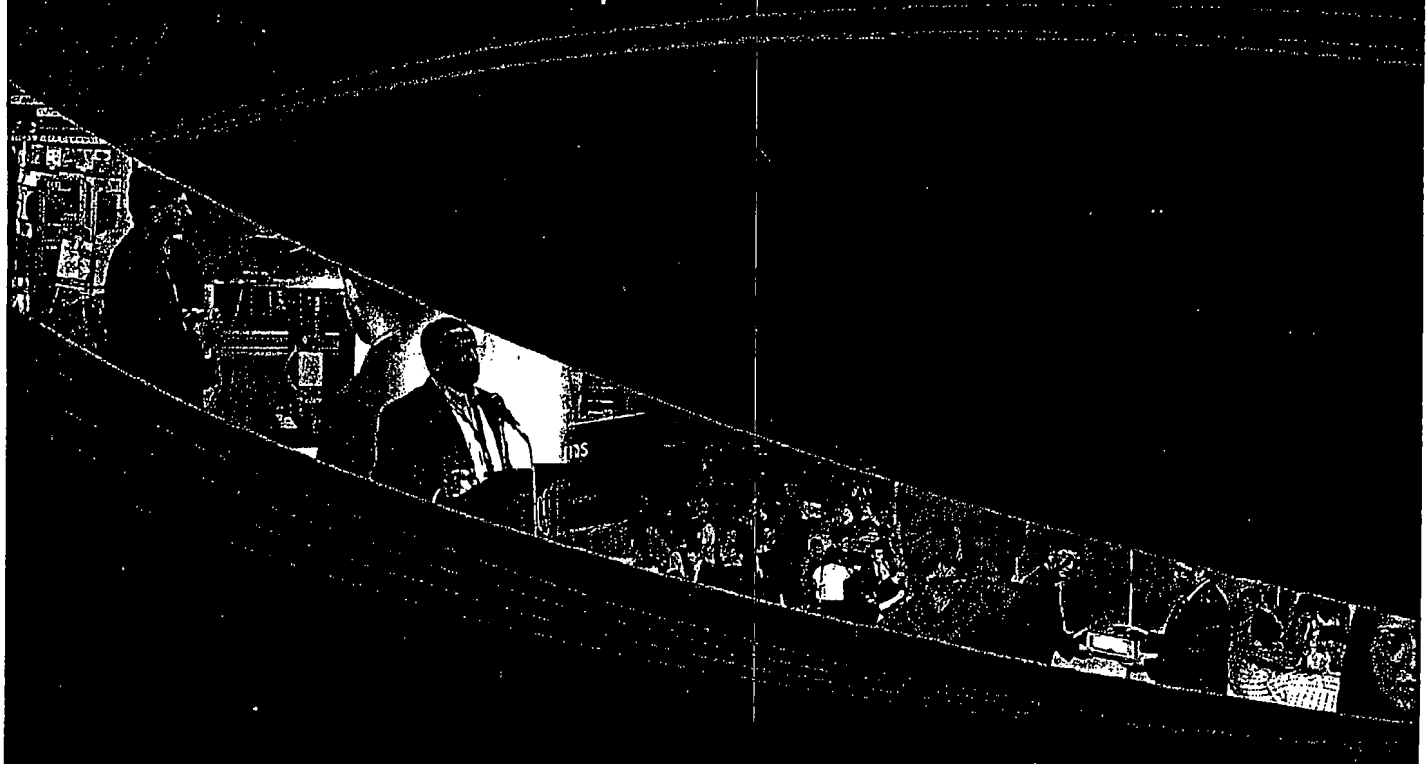
Exhibit C p.1

OFC 2003

OPTICAL FIBER COMMUNICATION
CONFERENCE & EXPOSITION

Postdeadline Papers

OFC brings together the People, Products and Information that drive optical communications.



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March 27, 2003
Georgia World Congress Center
Atlanta, Georgia, USA
www.ofcconference.org

Exhibit C p.2

4:00pm – 6:30pm

B406B-B407

Gary Carter, Univ. of Maryland Baltimore Campus, USA, Presider
Lynn E. Nelson, OFS Fitel Labs., USA, Presider
Loudon Blair, CIENA Corp., USA, Presider

PD18 4:00pm
DWDM 40G transmission over trans-Pacific distance (10,000km) using CSRZ-DPSK, enhanced FEC and all-Raman amplified 100km UltraWave™ fiber spans
C. Rasmussen, T. Fjelde, J. Bennike, F. Liu, S. Dey, B. Mikkelsen, P. Mamyshev, Mintera Corp., Lowell, MA, USA; P. Serbe, Huber+Suhner AG, Pfaeffikon, Switzerland; P. van der Wagt, Inphi Corp., Westlake Village, CA, USA; Y. Akasaka, D. Harris, Sprint, Advanced Tech. Labs., Burlingame, CA, USA; D. Gapontsev, V. Ivshin, P. Reeves-Hall, IPG Photonics Corp., Oxford, MA, USA.
We demonstrate error-free DWDM transmission of forty 40 Gbit/s channels with 100 GHz spacing over 10,000 km dispersion-managed fiber using CSRZ-DPSK, enhanced FEC and all-Raman amplified spans with 100 km terrestrial length.

PD19 4:15pm
6.4-Tb/s (160 x 42.7 Gb/s) transmission with 0.8 bit/s/Hz spectral efficiency over 32 x 100 km of fiber using CSRZ-DPSK format
B. Zhu, L. Nelson, S. Stulz, OFS, Holmdel, NJ, USA; A. Gnauck, C. Doerr, J. Leuthold, Lucent Tech., Holmdel, NJ, USA; L. Gruner-Nielsen, M. Pedersen, OFS, Brondby, Denmark; J. Kim, R. Lingle, OFS, Norcross, GA, USA; Y. Emori, Y. Ohki, N. Tsukiji, A. Oguri, S. Namiki, Fitel Photonics Labs., Chiba, Japan.
Carrier-suppressed, return-to-zero differential-phase-shift-keyed modulation format with strong signal filtering and balanced detection are employed to transmit one-hundred-sixty 40-Gb/s, 50-GHz-spaced channels over 3200 km of TrueWave® *REACH* fiber, a record capacity x distance product of 20 Pbit/s-km for terrestrial 40-Gb/s systems.

PD20 4:30pm
8370km with 22dB spans ULH transmission of 185*10.709Gbit/s RZ-DPSK channels
J. Marcerou, G. Vareille, L. Becouarn, Alcatel, Nozay, France;-P. Pecci, P. Tran, Alcatel, Marcoussis, France.
185*10.709 RZ-DPSK channels are transmitted at a distance of 8370km over 22dB spans using only with C-band EDFA. High potential of use of this transmission is highlighted with experiments exhibiting system margin above 5000km.

PD21 4:45pm
Experimental demonstration of net coding gain of 10.1 dB using 12.4 Gb/s block turbo code with 3-bit soft decision
T. Mizuochi, K. Ouchi, T. Kobayashi, Y. Miyata, K. Kuno, H. Tagami, K. Kubo, H. Yoshida, M. Akita, K. Motoshima, Mitsubishi Elec. Corp., Kamakura, Japan.
Turbo FEC for 10 Gb/s optical transmission has been experimentally demonstrated, for the first time. Using a newly developed 3-bit soft decision LSI, a record coding gain was achieved with only 24.6 % redundancy for an input BER of 1.98×10^{-2}.

PD22 5:00pm
A DWDM demonstration of 3.73Tb/s over 11,000km using 373 RZ-DPSK channels at 10Gb/s
J. Cai, D. Foursa, C. Davidson, Y. Cai, G. Domagala, H. Li, L. Liu, W. Patterson, A. Pilipetskii, M. Nissov, N. Bergano, Tyco Telecom., Eatontown, NJ, USA.
We present the first multi-terabit/s transoceanic length transmission demonstration using the RZ-DPSK format at a 10 Gb/s channel data rate. Error-free performance for 373 – 10 Gb/s RZ-DPSK channels after 11,000 km was demonstrated.

PD23 5:15pm
70GHz-spaced 40 x 42.7Gbit/s transmission over 8700km using CS-RZ DPSK signal, all-Raman repeaters and symmetrically dispersion-managed fiber span
T. Tsuritani, A. Agata, I. Morita, N. Edagawa, KDDI R&D Labs., Saitama, Japan; K. Ishida, K. Shimomura, T. Tokura, T. Mizuochi, Mitsubishi Electric Corp., Kanagawa, Japan; H. Taga, KDDI Submarine Cable Systems, Tokyo, Japan.
70GHz-spaced 40x42.7Gbit/s pre-filtered CS-RZ DPSK signals have been successfully transmitted over 8700km for the first time, using all-Raman repeaters, "ABA" dispersion map and an ETDM receiver. Long-term stability was also confirmed with low-speed polarization scrambling and without using PMD compensation.

PD24 5:30pm
High co-directional Raman gain for 200-km spans, enabling 40 x 10.66 Gb/s transmission over 2400 km
J. Bromage, H. Thiele, L. Nelson, S. Stulz, OFS, Holmdel, NJ, USA; J. Bouteiller, K. Brar, C. Headley, OFS, Somerset, NJ, USA; J. Kim, A. Klein, G. Baynham, R. Lingle, OFS, Norcross, GA, USA; L. Jorgensen, L. Gruner-Nielsen, OFS, Brondby, Denmark; D. DiGiovanni, OFS, Murray Hill, NJ, USA.
Using 200-km spans with 14.5-dB Raman co-gain, we transmitted 400 Gb/s error-free over 2400-km of TrueWave *REACH* fiber. With bidirectional Raman pumping, span lengths could be doubled, reducing operating expenses for medium- to long-haul systems.

PD25 5:45pm
Cost-optimized 6.3Tbit/s-capacity terrestrial link over 17x100km using phase-shaped binary transmission in a conventional all-EDFA SMF-based system
G. Charlet, S. Lanne, L. Pierre, C. Simonneau, P. Tran, H. Mardoyan, P. Brindel, J. Antona, M. Molina, J. Godin, S. Bigo, Alcatel Res. and Innovation, Marcoussis, France; M. Gorlier, P. Sillard, Alcatel Cable France, Conflans St Honorine, France; W. Idler, Alcatel Res. and Innovation, Stuttgart, Germany.
We demonstrate the feasibility of 6.3Tbit/s capacity over 17x100km using well-proven all-erbium-doped fiber amplifier technology over a typical ultra-long haul link based on standard fiber. This experiment emphasizes the advantages of our modulation format, namely phase-shaped binary transmission.

PD26 6:00pm
5,745 km DWDM transcontinental field trial using 10 Gbit/s dispersion managed solitons and dynamic gain equalization
A. Pratt, P. Harper, S. Alleston, P. Bontemps, B. Charbonnier, W. Forysiak, L. Gleeson, D. Govan, G. Jones, D. Nesset, J. Nijhof, I. Phillips, M. Stephens, A. Walsh, T. Widdowson, N. Doran, Marconi, Coventry, United Kingdom.
Error free unregenerated transmission is demonstrated looped-back over 5,745 km (62 spans) of installed SSMF along the Adelaide-Perth leg of the IP1 Australia network, which is now the world's longest commercially deployed unregenerated 10 Gbit/s DWDM terrestrial transmission system.

PD27 6:15pm
Terabit/s field trial over the first installed dispersion-flattened transpacific system
B. Bakhshi, D. Kovsh, G. Mohs, R. Lynch, M. Manna, E. Golovchenko, W. Patterson, M. Vaa, P. Corbett, M. Sanders, H. Li, G. Harvey, S. Abbott, Tyco Telecom., Eatontown, NJ, USA.
We present results of a successful field trial at 96 x 12.3 Gb/s per fiber over the first installed dispersion-flattened transpacific system, 8991-km long, part of the Tyco Global Network™, plus experimental results for 128 x 12.3 Gb/s over the same path.

4:00pm – 6:30pm

B312 – B313A
Ben Eggleton, Univ. of Sydney, Australia, Presider
George Harvey, Tyco Submarine Systems, USA, Presider

PD28 4:00pm
Reduction of chirped fiber grating group delay ripple penalty through UV post processing
M. Sumetsky, P. Westbrook, P. Reyes, N. Litchinitser, OFS Labs, Murray Hill, NJ; B. Eggleton, Univ. of Sydney, Sydney, Australia; Y. Li, R. Deshmukh, C. Soccolich, OFS, Somerset, NJ, USA; F. Rosca, J. Bennike, F. Liu, S. Dey, Mintera Corp., Lowell, MA, USA.
We demonstrate adiabatic UV correction of smoothed group delay ripple from ±10 ps to ±2 ps yielding reduction of OSNR penalty (40Gbit/s CSRZ) from ~ 4 dB to 0.5dB over the tunable dispersion range of 270 to 750 ps/nm.

PD29 4:15pm
Channelized dispersion compensator with flat pass bands using an array of deformable MEMS mirrors
D. Neilson, R. Ryf, D. Marom, S. Chandrasekhar, Bell-Labs Lucent Tech., Holmdel, NJ, USA; F. Pardo, V. Aksyuk, M. Simon, Bell-Labs., Lucent Tech., Murray Hill, NJ, USA; D. Lopez, New Jersey Nanotech. Consortium, Murray Hill, NJ, USA.
Continuously variable and independently addressable channelized dispersion is produced by an array of MEMS adaptable curvature mirrors employed in a novel optical configuration. A per channel variable dispersion greater than +/-400ps/nm was demonstrated, with 56GHz +/-0.4dB flat passband on 85GHz spacing.

PD30 4:30pm
Fiber Bragg gratings (FBG) made with a phase mask and 800 nm femtosecond radiation
S. Mihailov, C. Smelser, P. Lu, R. Walker, D. Grobnic, H. Ding, Comm. Res. Ctr. Canada, Ottawa, ON, Canada; J. Unruh, Photronics Inc., Allen, TX, USA.
FBG's were written in SMF-28 fiber, without fiber sensitization, using 800 nm 120 fs pulses and a phase mask (peak intensities: 1.2×10^{13} W/cm^2). Gratings with $\Delta n = 1.85 \times 10^{-3}$ and low polarization dependence were stable at 500°C.

PD31 4:45pm
Lithographically scribed, focusing, planar holographic bragg reflector with 17-GHz passband and 0.3 cm^2 footprint
C. Greiner, D. Iazikov, T. Mossberg, LightSmyth Tech., Eugene, OR, USA.
A focusing holographic Bragg reflector in a slab waveguide is demonstrated to provide 17 GHz, essentially Fourier-transform-limited, spectral resolution and nearly diffraction-limited, spatial-beam mapping in a device footprint of only 0.3 cm^2.

Exhibit C p.4

OFC:04

Optical Fiber Communication Conference & Exposition

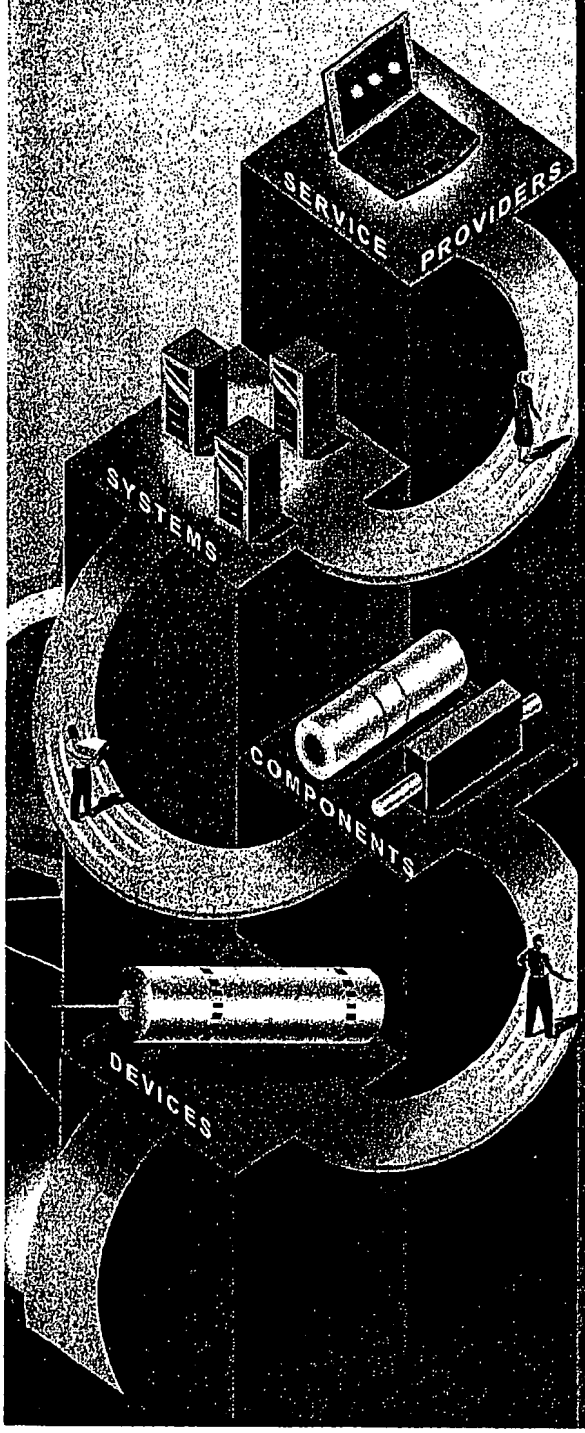

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Exhibit C p.5

PDP32 5:00 p.m.
Compensation of intra-channel nonlinearities in 40 Gb/s pseudo-linear systems using optical phase conjugation, *Aref Chowdhury, Gregory Raybon, Rene Jean Essiambre, Jeffrey Sinsky, Andrew Adamiecki, Juerg Leuthold, Christopher R. Doerr, Sethumadhavan Chandrasekhar; Bell Labs., USA.* We compensate intra-channel nonlinearities in an RZ-DPSK-40Gb/s 32×100km system using a $LiNbO_3$ conjugator and achieve 2 decades of improvement in BER. Transmission limited to 5,200km at a BER=5×10^{-4} is extended to 6,400km with phase conjugation.

PDP33 5:15 p.m.
Direct measurement of constellation diagrams of optical sources, *Christophe Dorrer, Juerg Leuthold, Christopher R. Doerr; Bell Labs, Lucent Technologies, USA.* We present the first temporal diagnostic that measures statistical information on both the intensity and phase of data-encoded channels. Experimental characterization of differential-phase shift keyed signals at 10 Gb/s and 40 Gb/s is presented.

Subcommittee F: Digital Transmission Systems
Alan Gnauck, ***Lucent Technologies, Bell Labs., USA,*** **Presider**

PDP34 5:30 p.m.
RZ-DPSK field trial over 13,100 km of installed non slope-matched submarine fibers, *Jin-Xing Cai, Dmitri Foursa, Li Liu, Carl Davidson, Yi Cai, Will Patterson, Alan Lucero, Bamdad Bakhshi, Georg Mohs, Pat Corbett, Vishal Gupta, William Anderson, Michael Vaa, George Domagala, Matt Mazurczyk, Haifeng Li, Morten Nissov, Alexei Pilipetskii, Neal Bergano; Tyco Telecommunications, USA.* We successfully conducted a 96x10Gb/s RZ-DPSK field trial over an installed 13,100km optical undersea path with more than 3dB FEC margin, including channels with >13,000ps/nm dispersion. The performance was further improved 1-2dB by adding pre-chirp.

PDP35 5:45 p.m.
6 x 42.7 Gb/s transmission over ten 200 km EDFA-amplified SSMF spans using polarization-alternating RZ-DPSK, *A. H. Gnauck[1], J. Leuthold[1], C. Xie[1], I. Kang[1], S. Chandrasekhar[1], P. Bernasconi[1], C. Doerr[1], L. Buhl[1], J. D. Bull[2], N. A. F. Jaeger[2], H. Kato[2], A. Guest[2]; [1]Lucent Technologies, Bell Labs, USA, [2]JGKB Photonics, Canada.* We demonstrate the use of polarization alternation to dramatically improve performance in 42.7-Gb/s WDM transmission. Six channels are transmitted through ten 200-km (39-dB loss) standard-single-mode fiber spans with amplification provided solely by erbium-doped fiber amplifiers.

PDP36 6:00 p.m.
WDM transmission at 6 Tbit/s capacity over transatlantic distance, using 42.7Gb/s Differential Phase-Shift Keying without pulse carver, *Gabriel Charlet[1], Erwan Corbel[1], Jose Lazaro[2], Axel Klekamp[2], Roman Dischler[2], Patrice Tran[1], Wilfried Idler[1], Haik Mardoyan[1], Agnieszka Konczykowska[3], Filipe Jorge[3], Sebastien Bigo[1]; [1]Alcatel R&I, France, [2]Alcatel R&I, Germany, [3]Opto+, France.* We report the transmission of a record 6Tbit/s capacity over 6,120km, involving channels modulated at 42.7Gb/s bit-rate with Differential Phase-Shift Keying (DPSK). The performance is found similar to DPSK with subsequent pulse carving, namely RZ-DPSK.

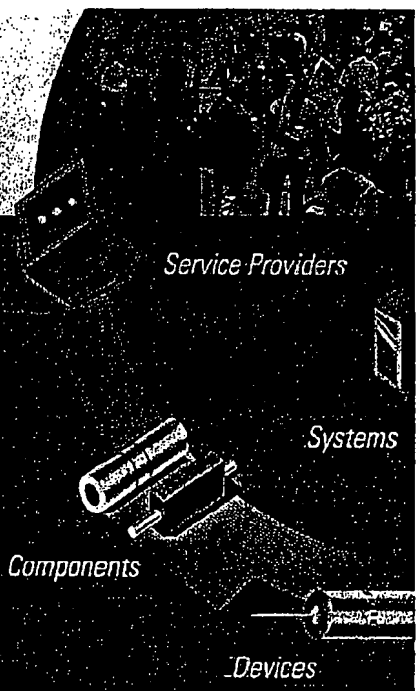
PDP37 6:15 p.m.
42 × 42.7 Gb/s RZ-DPSK transmission over a 4820 km long NZDSF deployed line using C-band-only EDFAs, *Loic Becouarn[1], Ghislaine Vareille[1], Sebastien Dupont[1], Philippe Plantady[1], Jean-François Marcerou[1], Axel Klekamp[2], Roman Dischler[2], Wilfried Idler[2], Gabriel Charlet[1]; [1]Alcatel, France, [2]Alcatel, Germany.* The transmission of 42 RZ-DPSK channels at 42.7Gb/s is demonstrated over 4820 km of NZDSF deployed line with more than 3dB margin. A performance comparison with the same capacity using 166× 10Gb/s DPSK is demonstrated.

PDP38 6:30 p.m.
1.14 b/s/Hz spectrally-efficient 50 x 85.4 Gb/s transmission over 300 km using copolarized CS-RZ DQPSK signals, *Noboru Yoshikane, Itsuro Morita; KDDI R&D Labs. Inc., Japan.* 1.14 b/s/Hz spectrally-efficient 50 x 85.4 Gb/s transmission over 300 km of NZ-DSF has been successfully demonstrated with copolarized CS-RZ DQPSK signals. 42.7 Gsymbol/s-based 4Tb/s DQPSK transmission has been achieved without polarization multiplexing.

Exhibit C p.6

S. CHANDRITSEKHAR

LINKING THE SCIENCE AND BUSINESS OF OPTICAL COMMUNICATIONS



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PDP22 4:15 p.m.
A Lead Silicate Holey Fiber with $\gamma = 1820\ W^{-1}km^{-1}$ at 1550 nm
Julie Y. Y. Leong, Periklis Petropoulos, Symeon Asimakis, Heike Ebendorff-Heidepriem, Roger C. Moore, Ken Frampton, Vittoria Finazzi, Xian Feng, Jonathan H. Price, Tanya M. Monro, David J. Richardson; Optoelectronics Res. Ctr., UK.
We report the fabrication of lead silicate holey fibers with record nonlinearities of up to $1860W^{-1}m^{-1}$ at 1.55μm. Broadband supercontinuum generation is obtained in a dispersion optimized fiber variant at ~100pJ pulse energies for 1.06μm pumping.

PDP23 4:30 p.m.
Wavelength Conversion of 40-Gbit/s NRZ Signal Using Four-Wave Mixing in 40-cm-long Bismuth Oxide Based Highly-Nonlinear Optical Fiber
Ju Han Lee[1], Tatsuo Nagashima[2], Tomoharu Hasegawa[2], Seiki Ohara[2], Naoki Sugimoto[2], Takuo Tenermura[1], Kazuro Kikuchi[1]; [1]RCAST, Univ. of Tokyo, Japan, [2]Asahi Glass Co., Ltd, Japan.
We demonstrate the use of an only 40-cm-long Bi_2O_3-based nonlinear fiber with γ=1100 $W^{-1}km^{-1}$ to obtain FWM-based wavelength conversion. Error-free conversion of 40-Gbit/s NRZ signals over ~10 nm is achieved without any SBS suppression scheme

PDP24 4:45 p.m.
Cancellation of Intensity Noise Caused by Stimulated Brillouin Scattering in an Optical Fiber Transmission System
Jinye Zhang, M. R. Phillips; Northwestern Univ., USA.
The primary source of broadband intensity noise on an SBS-degraded optical signal is found to be deterministic and depend on the imaginary part of the Brillouin loss spectrum. The noise is reduced by subsequent transmission through a Brillouin amplifier.

PDP25 5:00 p.m.
Single-Mode Performance in Multimode Fibre Devices
S. G. Leon-Saval[1], T. A. Birks[1], J. Bland-Hawthorn[2], M. Englund[3]; [1]Univ. of Bath, UK, [2]Anglo-Australian Observatory, Australia, [3]Redfern Optical Components, Australia.
We demonstrate a waveguide transition between a multimode fibre and several single-mode fibres. Splicing identical Bragg gratings between two such transitions yields a multimode fibre filter with the transmission spectrum of a single-mode fibre grating.

Subcommittee F. Digital Transmission Systems
Carl Davidson, *Tyco Communications, USA*, Presider

PDP26 5:15 p.m.
Transmission of 40 Gb/s WDM Signals over 6,250 km of Conventional NZ-DSF with >4 dB FEC Margin
Jin-Xing Cai, Carl R. Davidson, Morten Nissov, Haifeng Li, William Anderson, Yi Cai, Li Liu, Alexei N. Pilipetskii, Dmitri G. Foursa, William W. Patterson, Patrick C. Corbett, Alan J. Lucero, Neal S. Bergano; Tyco Telecommunications, USA.
We successfully transmitted 18x40Gb/s RZ-DPSK channels over 6,250km of non-slope-matched-fibers with >4dB FEC margin using dispersion-slope compensators at the receiver. We demonstrated that 40Gb/s DPSK worked as well as 10Gb/s RZ-OOK for the same spectral efficiency.

PDP27 5:30 p.m.
5120 km RZ-DPSK Transmission over G652 Fiber at 10 Gb/s with No Optical Dispersion Compensation
Doug McGhan, Charles Laperle, Alexander Savchenko, Chuandong Li, Gary Mak, Maurice O'Sullivan; Nortel, Canada.
We report the longest un-regenerated reach achieved for a 10 Gb/s return-to-zero differential phase shift keying (RZ-DPSK) system on standard dispersion fiber (G652) with no optical dispersion compensation.

PDP28 5:45 p.m.
10,200km 22x2x10Gbit/s RZ-DQPSK Dense WDM Transmission without Inline Dispersion Compensation through Optical Phase Conjugation
Sander L. Jansen[1], Dirk van den Borne[1], Carlos Climent[2], Murat Serbay[3], Claus-Joerg Weiske[2], Herbertus Suche[4], Peter Krummrich[2], Stefan Spaelter[2], Stefano Calabrò[2], Nancy Hecker-Denschlag[2], Patrick Leisching[2], Werner Rosenkranz[3], Wolfgang Solher[4], Giok-Djan Khoe[1], Tom Koonen[1], Huug de Waardt[1]; [1]Eindhoven Univ. of Technology, Netherlands, [2]Siemens AG, Germany, [3]Univ. of Kiel, Germany, [4]Univ. of Paderborn, Germany.
Using optical phase conjugation with a polarization independent periodically-poled lithium-niobate subsystem, we demonstrate dense WDM 2x10Gbit/s RZ-DQPSK transmission over 10,200km of SSMF with a record accumulated dispersion, exceeding 80,000ps/nm.

PDP29 6:00 p.m.
Coherent Demodulation of 40-Gbit/s Polarization-Multiplexed QPSK Signals with16-GHz Spacing after 200-km Transmission
Satoshi Tsukamoto, Dany-Sebastien Ly-Gagnon, Kazuhiro Katoh, Kazuro Kikuchi; Univ. of Tokyo, Japan.
40-Gbit/s polarization-multiplexed QPSK signals with 16-GHz spacing are demodulated after 200-km transmission by using a homodyne phase-diversity receiver. The highlights of our scheme are electrical post-filtering and digital signal processing that enhance the BER performance.

Subcommittee G. Subsystems, Network Elements, and Analog Systems
Kim Roberts, *Nortel Networks, USA*, Presider

PDP30 6:15 p.m.
Flexible Transport at 10-Gb/s from 0 to 675km (11,500ps/nm) Using a Chirp-Managed Laser, No DCF, and a Dynamically Adjustable Dispersion-Compensating Receiver
Sethumadhavan Chandrasekhar[1], Christopher R. Doerr[1], Lawrence L. Buhl[1], Daniel Mahgerefteh[2], Y. Matsui[2], B. Johnson[2], C. Liao[2], X. Zheng[2], K. McCallion[2], Z. Fan[2], P. Tayebati[2]; [1]Bell Labs, Lucent Technologies, USA, [2]AZNA Corp., USA.
We demonstrate continuous detectability of 10-Gb/s data from 0 to 675 km of standard single mode fiber without in-line dispersion compensation using a combination of a chirp-managed laser and tunable optical and electronic dispersion compensation at the receiver.

PDP31 6:30 p.m.
Linear Microwave-Domain Dispersion Compensation of 10-Gb/s Signals Using Heterodyne Detection
Alan H. Gnauck, Jeff Sinsky, Peter J. Winzer, Sethumadhavan Chandrasekhar; Bell Labs, Lucent Technologies, USA.
We demonstrate heterodyne detection of 10-Gb/s signals, and subsequent linear compensation of fiber chromatic dispersion in the microwave domain. We achieve 375-km transmission (with 2-dB penalty) over standard single-mode fiber using duobinary modulation and a single passive microwave dispersion-compensating element.

Room: Ballroom D
Session: Postdeadline IV
4:00 p.m. – 6:45 p.m.

Subcommittee G. Subsystems, Network Elements, and Analog Systems
Kim Roberts, *Nortel Networks, USA*, Presider

PDP32 4:00 p.m.
Demonstration of 2.5 Gslot/s Optically-Preamplified M-PPM with 4 Photons/Bit Receiver Sensitivity
David O. Caplan, Bryan S. Robinson, Robert J. Murphy, Mark L. Stevens; MIT Lincoln Lab, USA.
Photon-efficient optical communications using variable-duty-cycle M-ary pulse-position modulation (M-PPM) with coding is investigated experimentally using a simple, multi-rate nearly quantum-limited receiver with throughputs ranging from 1.25 Gbit/s in the binary case, to 78 Mbit/s for M=256.